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GB0213385.8

By virtue of a direction given under Section 30 of the Patents Act 1977, the application is proceeding in the name of

MARCONI UK INTELLECTUAL PROPERTY LTD
Incorporated in the United Kingdom
PO Box 53
New Century Park
Coventry
CV3 1HJ
United Kingdom

[ADP No. 08660763001]

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1. Your reference — PADL/JCH/43882

2. Patent application number *(The Patent Office will fill in this part)* — 0213385.8 — 11 JUN 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)* — ~~Marconi Communications Limited~~
PO Box 53
New Century Park
Coventry
CV3 1HJ

SECTION 30 (1977 ACT) APPLICATION FILED

Patents ADP number *(if you know it)* — 7894538001

17-06-03

If the applicant is a corporate body, give the country/state of incorporation — England & Wales

4. Title of the invention — MAXIMISING POWER IN OPTICAL COMMUNICATIONS NETWORKS

5. Full name, address and postcode in the United Kingdom to which all correspondence relating to this form and translation should be sent — Reddie & Grose
16 Theobalds Road
LONDON
WC1X 8PL

Patents ADP number *(if you know it)* — 91001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application *(if you know it)*	Date of filing *(day/month/year)*

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DUPLICATE

MAXIMISING POWER IN OPTICAL COMMUNICATIONS NETWORKS

43882

This invention relates to optical communications networks, and in particular to maximising power available to launch signals onto optical communications networks.

The design of photonics systems requires that the OSNR (optical signal to noise ratio) is above a given minimum value over the longest path under the worst case conditions.

We have appreciated that many of the channels of the system do not require this performance as they are of a lower bandwidth or do not need to travel the maximum distance. A limiting feature of optical amplifiers is the power available. This may be due to safety constraints or cost. The maximum output power of an amplifier is conventionally divided equally amongst all the channels being transmitted. Higher bit ratio channels such as 10Gbit/s require a better OSNR than lower bit rate channels such as 2.5Gbit/s channels. For a given system performance OSNR can only be improved by increasing the transmission power.

The invention aims to maximise the power available to signals requiring a higher bandwidth and or greater path length. Broadly, this is achieved by dividing available output power amongst the channels according to their individual bandwidth/distance requirements.

More specifically, there is provided a method of controlling signal launch power in an optical communications network, comprising adjusting the launch power in accordance with a measure of a signal amplitude determined after amplification of the signal.

The invention also provides apparatus for controlling launch power in an optical communications network comprising a launcher for launching a signal onto the network,

amplifying the launched signal, a feedback path for feeding back a parameter of the amplified signal to the signal launcher and means for varying the launch power of the launched signal in accordance with the feedback signal parameter.

The invention further provides an add/drop node for an optical communications network, the node comprising a signal launcher for launching a signal onto the network as part of an n channel multiplex, an amplifier for amplifying the signal multiplex on the network, means for deriving a reference signal from the output of the amplifier indicative of a parameter of the signal launched by the signal launcher, and a controller for adjusting the signal launch power at the launcher in accordance with the reference signal.

The parameter measured may be the signal bandwidth enabling the launch power to be set according to the bandwidth of the signal. This has the advantage that launch power can be conserved and redirected to maximise the bandwidths that can be transmitted and to increase the path lengths over which signals can be transmitted.

Preferably, the optical communications network carries an n channel signal multiplex, and a plurality of signals are launched from a network node, a signal parameter of each signal launched from the node is measured and the relative launch powers of the signals is adjusted in accordance with the measured signal parameters.

Preferred embodiments have the advantage that for a given launch power available at an add/drop node, the power can be distributed amongst the channels in accordance with the requirements of each channel. This again can increase the bandwidth that can be sent and increase the transmission distance that can be achieved.

Preferably, an attribute of the signal path is determined from launch of the signal to reception at its intended destination and the launch power is varied in [illegible] accordance.

In one preferred embodiment the OSNR of the signal is determined at the receiver.

Preferably, the signal attribute is determined for each of the channels launched from the node so that the optimum relative launch power can be determined.

Information about the signal path, such as the route may be determined from a network manager enabling the likely noise on the path to be calculated.

An embodiment of the invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram illustrating the principal of the invention;

Figure 2 is a schematic diagram showing how launch power can be adjusted according to the connection path; and

Figure 3 shows the use of a network manager on an optical ring network.

The embodiments described divide the available output power amongst the channels according to individual bandwidth requirements. The higher the bit rate, the higher the power level allocated to that channel ensuring that all channels are launched such that they are received with adequate OSNR.

The power output for a given channel can also be controlled according to the bandwidth of the terminating receiver and according to the number and type of network elements the signal is to pass through. Feedback of path performance from the receiving end, transmitted back via a telemetry channel can be used to further modify the transmitted signal power to optimise the available system performance.

Referring to Figure 1, an optical amplifier 10 amplifies an optical signal on a fibre 11. The output is split at a coupler 12 providing an output signal path 13 and a feedback control path 15. The feedback control path is demultiplexed by a demultiplexer 14 the outputs of which each have a pin diode 16 attached to convert the individual channels signals into electrical signals. Only one is shown

in Figure 1 for simplicity. The electrical signals are amplified by amplifier 18 and then passed to transponders 20; the outputs of which are connected to a controller 22 the outputs of which are connected to transponder 20 or CCU 23 depending on whether a channel is being added or passed through. The controller receives an input form a shelf management unit 24 and can, knowing the power of the channel, its bandwidth and potentially the OSNR of the path, alter the launched power of the channel to optimise it. Thus, for example, it can be ensured that the signal is not launched with too much power as this would waste a power resource that could be directed to a higher bit rate channel.

It will be appreciated that Figure 1 only shows one channel. In practice, the amplifier will amplify a number of channels, for example up to 32. Each channel will carry a different signal having a different bandwidth and, therefore a different launch power requirement. The system manager can evaluate each signal's power requirement for its known bandwidth and or received quality from the termination of the path. The system manager can then formulate a target power level for the controller to set the launched power level. Thus, the available launch power is not simply divided equally across the channels but distributed according to a measure of channel power requirement, such as signal bandwidth determined from the amplified output of each channel.

Turning now to Figure 2, the circuit illustrated schematically shows how the connection path can be determined. The figure illustrates a portion of an add/drop node which adds signals on to the network. A reference is derived from this signal and information about the signal is communicated back to the add/drop node transponder from the eventual receiver to inform the transponder of the signal path, allowing the power to be adjusted to give an adequate OSNR at the receiver.

Thus, the add side of the add/drop node comprises a channel control unit 30 to control through traffic and an add coupler 32 for addition of signals to the network. The signals to be added are provided from the transmitters of the node transponders 34 which output a number of signals on separate channels, for example up to 32. These signals are multiplexed together by an optical multiplexer 36 and the signal multiplex added onto the network by the coupler 32.

The output of the coupler is amplified by an amplifier 38 and a signal split from the main network path to derive a reference signal by a splitter coupler 40. The coupler 40 has two outputs: a through output 42 which is the main network path, and a drop path 44 from which the reference signal is derived. The drop path 44 carries the dropped signal multiplex to a demultiplexer 46 where it is split into its component channels. A feedback signal is derived for each of the these channels, one only of which is shown in Figure 2. The optical output of the channel from demultiplexer 46 is converted to an electrical signal by photodiode 48, amplified by amplifier 50 and fed back to the Controller block where the feedback signal is compared with a reference signal and a control output generated to adjust the transponder. The reference signal is derived from the signal bandwidth and information received back from the far end of the path.

The signal on the through path continues around the network until it reaches its destination, whereupon the signal is dropped to a receiver. Where a channel passes through a node the levelling controller block will control the amplitude of the channel for the current received relative amplitude. The signal will pass through various stages of processing depending on how long it stays on the network. Each of these will introduce an amount of noise onto the signal. In the example of Figure 2, the signal is shown as passing through three amplification stages 52, 54, 56 by way of example. Each of these adds an element of noise

N to the signal. Thus, the total signal noise will depend on the route taken by the signal to its destination.

This signal is eventually dropped to the receiving node by a split coupler 58, filtered by a band pass filter 60 to isolate the signal channel and passed to a receiver Rx 62 where it is converted to an electrical signal for the user the receiver feeds back information to the add node controller block 22 detailing the noise on the received signal. The controller block 22 thus knows the noise on the signal at the receiver, and the bandwidth of the signal and can adjust the launch power of the signal accordingly.

The transponder seeks to send the signal with just sufficient power to exceed the minimum OSNR thereby optimising power utilisation. As with the previous example of Figure 1, the signal feedback is performed on all signals transmitted at the transponder 34 and the Controller seek to distribute the launch power to optimise the power for the bandwidth and paths of the signals.

In Figure 2, the feedback from the final receiver to add/drop node transponder is shown as a direct connection. It will be appreciated that this reference channel is passed across the network in a management channel.

As an alternative to a direct feedback from the receiver, signal routing can be obtained from a network manager. Figure 3 shows schematically how a network manager is attached to a ring network 60, to manage the flow of traffic between the various nodes 70. The various amplifiers between the nodes, such as amplifiers 52, 54 and 56 operate at a constant gain. It is therefore possible for the network manager to determine the noise contribution of each amplifier and to determined the signal path. Thus, the network manager can provide the add/drop node transponder launching the signal with an indication of the likely noise on the signal. The network manager will always be aware of the signal path, including, for example, cases where a signal is sent round [illegible]

fibre ring network, due to a component failure or the like on the shorter path.

It will be appreciated from the above description that embodiments of the invention have the advantage of allowing the launch power for a signal to be chosen according to parameters of the signal such as bandwidth and signal path. This enables available launch power to be distributed intelligently according to channel requirements. Moreover, it can enable other channels to be used at higher bandwidths or greater distances than would otherwise be possible.

Various modifications to the embodiments described are possible and will occur to those skilled in the art without departing from the scope of the invention which is defined by the following claims.

CLAIMS

1. A method of controlling signal launch power in an optical communications network, comprising adjusting the launch power in accordance with a measure of a signal parameter determined after amplification of the signal.

2. A method according to claim 1, wherein the optical communications network carries a n channel signal multiplex, wherein a plurality of signals are launched from a network node, comprising measuring a signal parameter of each signal launched from the node and adjusting the relative launch powers of the signals in accordance with the measured parameter of the signals.

3. A method according to claims 1 or 2, wherein the measured parameter is signal bandwidth.

4. A method according to claim 1, 2 or 3, comprising determining an attribute of the signal path from launch of the signal to reception and adjusting the launch power in accordance with the attribute of the signal path.

5. A method according to claim 4, wherein the adjustment in accordance with an attribute of the signal path is based on path length.

6. A method according to claim 4 or 5, wherein the adjustment in accordance with an attribute of the signal path is based on noise in the signal path.

7. A method according to claim 4, 5 or 6, wherein the [illegible]

signal path is based on a measure of path performance at the receiver.

8. A method according to any of claims 4 to 7, wherein the signal path is determined from a network manager attached to the optical communications network.

9. A method according to an of claims 4 to 8, wherein one or more parameters of the signal path are fed back to the signal source from the signal receiver.

10. A method according to claim 9, wherein the one or more signal path parameters include the optical signal to noise ratio (OSNR) of the signal received at the receiver.

11. A method according to any of claims 4 to 10, wherein the signal is one of a plurality of signals launched from a network node transponder, wherein the launch power of the signal relative to the launch power of others of the plurality of signals is adjusted in accordance with the determination of the signal path attribute.

12. Apparatus for controlling launch power in an optical communications network comprising a launcher for launching a signal onto the network, amplifying the launched signal, a feedback path for feeding back a parameter of the amplified signal to the signal launcher and means for varying the launch power of the launched signal in accordance with the feedback signal parameter.

13. Apparatus according to claim 12, wherein the optical communications network carries an n channel signal multiplex, wherein said signal launcher launches a plurality of signals onto the network, and wherein each

of the plurality of launched signals is amplified by the amplifier, comprising a feedback path for feeding back a parameter of each of the amplified signals to the signal launcher and wherein the launch power varying means comprises means for varying the relative launch powers of each of the plurality of signals.

14. Apparatus according to claim 13, wherein the signals are launched from an add/drop node transponder.

15. Apparatus according to claim 12, 13 or 14 comprising means for determining an attribute of the signal path from launch of the signal to reception and means for adjusting the launch power of the signal in accordance with the signal path attribute.

16. Apparatus according to claim 15, wherein the signal path attribute is the path length.

17. Apparatus according to claim 15 or 16, wherein the signal path attribute is the optical noise in the signal path.

18. Apparatus according to claim 15, 16 or 17, wherein the signal path attribute is a measure of path performance at the receiver.

19. Apparatus according to any of claims 15 to 18, comprising a network manager attached to the network for determining the signal path.

20. Apparatus according to any of claims 15 to 19, wherein the signal is received by a receiver connected to the network and to which the signal is dropped, the receiver including means for feeding back to the launcher one or more parameters of the signal.

21. Apparatus according to claim 20, wherein the one or more signal parameters include the optical signal to noise ratio of the signal received at the receiver.

22. Apparatus according to any of claims 15 to 21, wherein the signal is one of a plurality of signals launched from network node transponders, wherein the transponders include a controller for varying the relative launch power of each of the plurality of signals in accordance with one or more attributes of the signal paths fed back to the transponder.

23. An add/drop node for an optical communications network, comprising a signal launcher for launching a signal onto the network as part of an n channel multiplex, an amplifier for amplifying the signal multiplex on the network, means for deriving a reference signal from the output of the amplifier indicative of a parameter of the signal launched by the signal launcher, and a controller for adjusting the signal launch power at the launcher in accordance with the reference signal.

24. An add/drop node according to claim 23, wherein the signal launcher launches a plurality of signals into the network and the means for deriving a reference signal derives a reference signal from the amplifier output for each of the launched signals, wherein the controller varies the relative launch powers of the signals in accordance with the reference signals.

25. An add/drop node according to claim 24, wherein the controller further varies the relative launch power in accordance with a further reference signal received from the network and indicative of a parameter of the signal path of the launched signals around the network to a receiver.

26. A method of controlling signal launch power in an optical communications network, substantially as herein described with reference to Figures 1 to 3 of the accompanying drawings.

27. Apparatus for controlling signal launch power in an optical communications network, substantially as herein described with reference to Figures 1 to 3 of the accompanying drawings.

ABSTRACT

MAXIMISING POWER IN OPTICAL COMMUNICATIONS NETWORKS

(Fig. 2)

The relative launch power of signals at an add/drop node transponder is controlled to maximise available power. Signal bandwidth is fed back from an output of an amplifier on the network and signal path information is fed back from the signal receiver or the network manager. The transponders then know the bit rate of the signal and the likely noise in the signal path and can optimise the launch power accordingly.

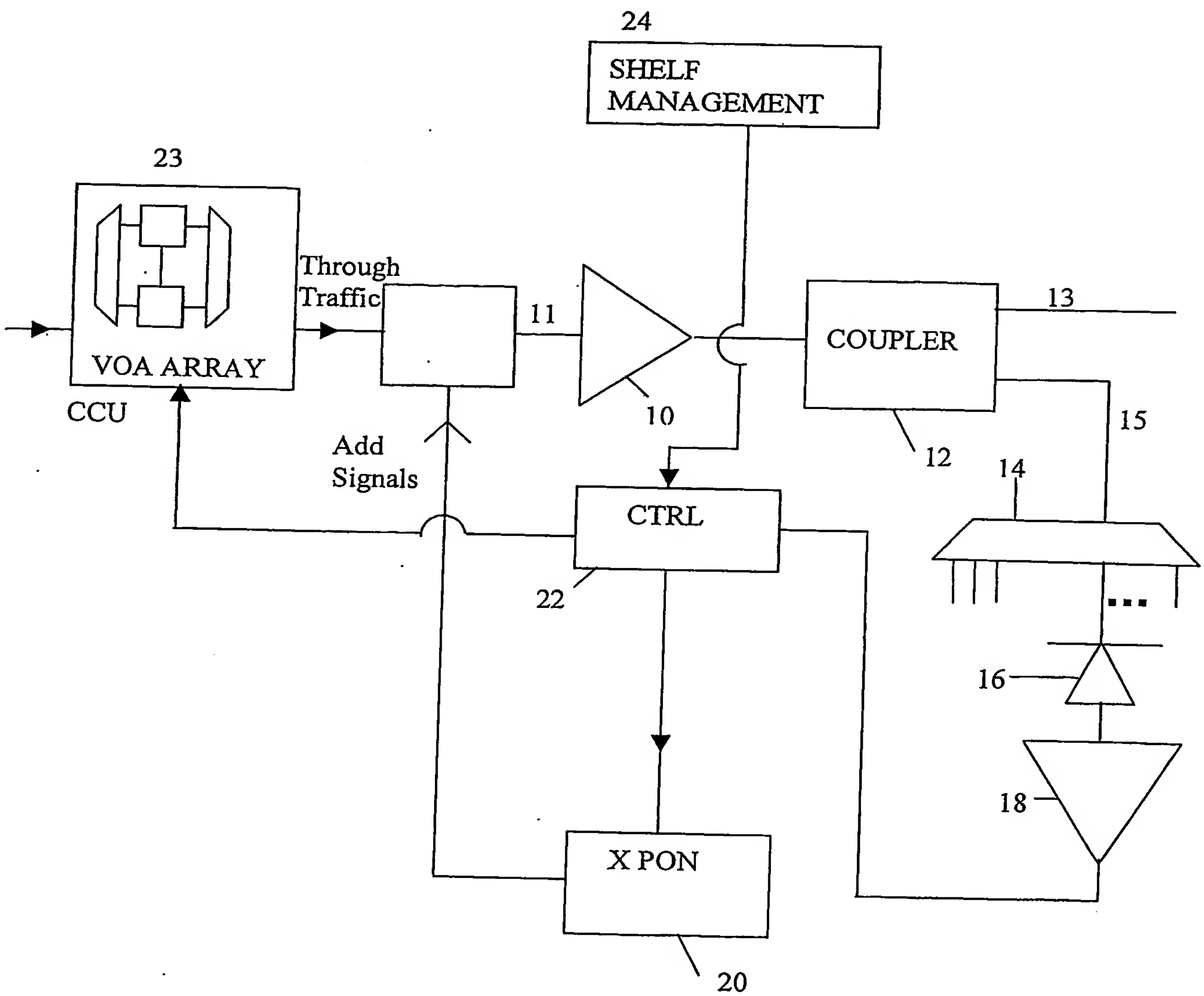
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Figure 1

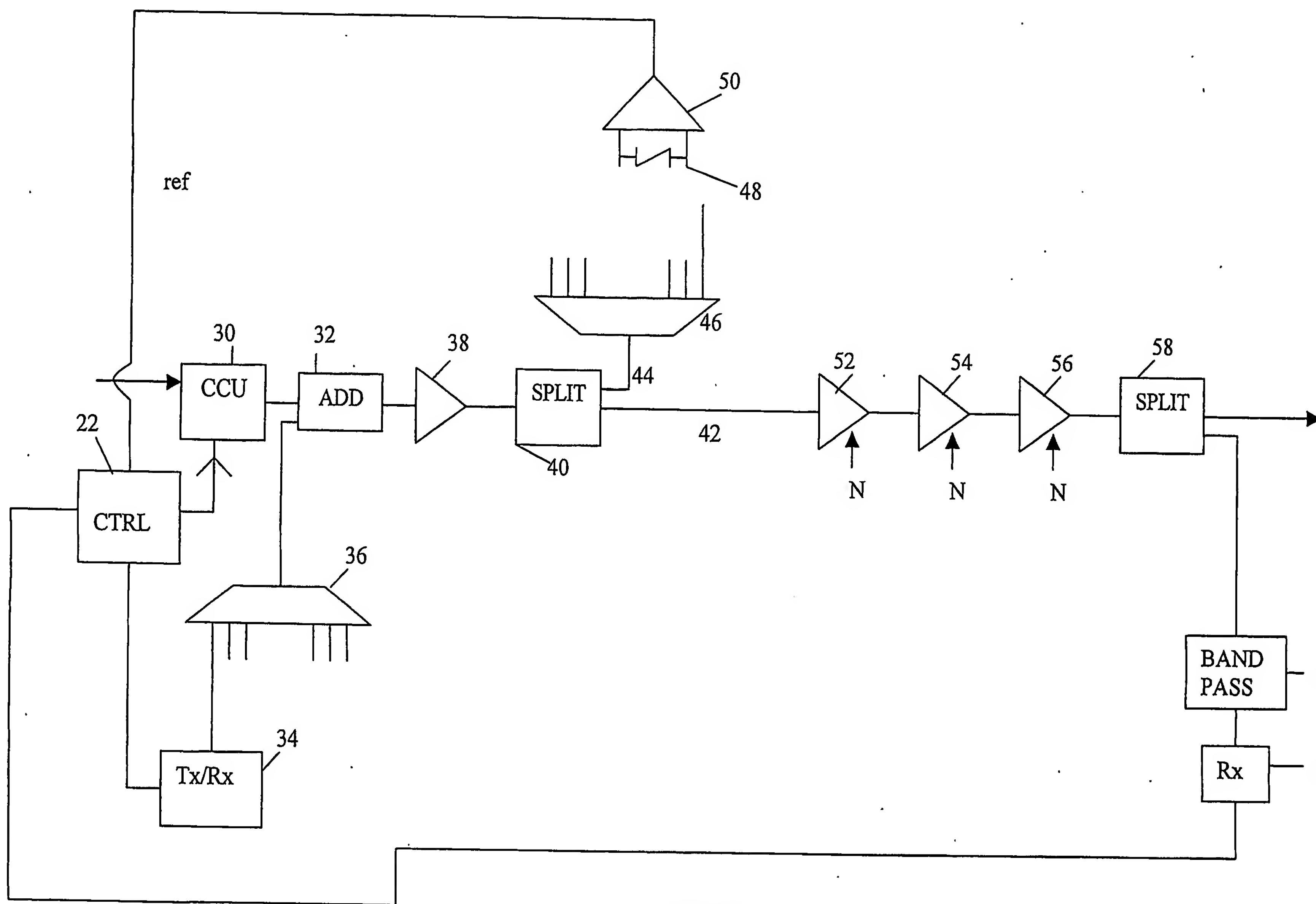
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Figure 2

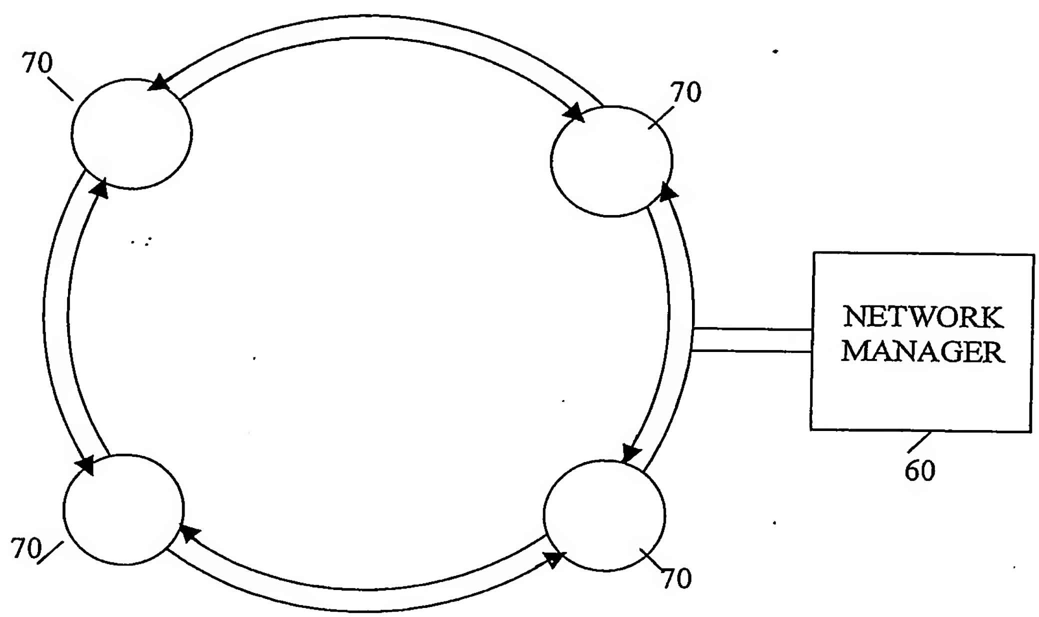

Figure 3